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INDEX

	PAGE
EDITORIAL NOTES :—	
Road Accidents in England and Wales	167
NOTES AND NEWS ON ILLUMINATION	168
Iso-candles for Amateurs, by Dr. John W. T. Walsh ...	169
A Statistical Review of Street Accidents	174
LIGHTING LITERATURE	177
Lighting Service Bureau Touring Demonstration... ...	180
Floodlighting the Royal Bath Hotel, Bournemouth ...	182
Illuminating Engineering in Japan	183
Street Refuge Lighting...	186
DIRECTORY OF LIGHTING EQUIPMENT...	194

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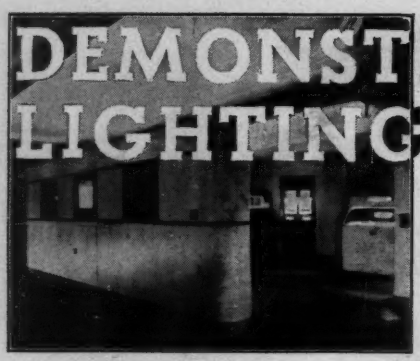

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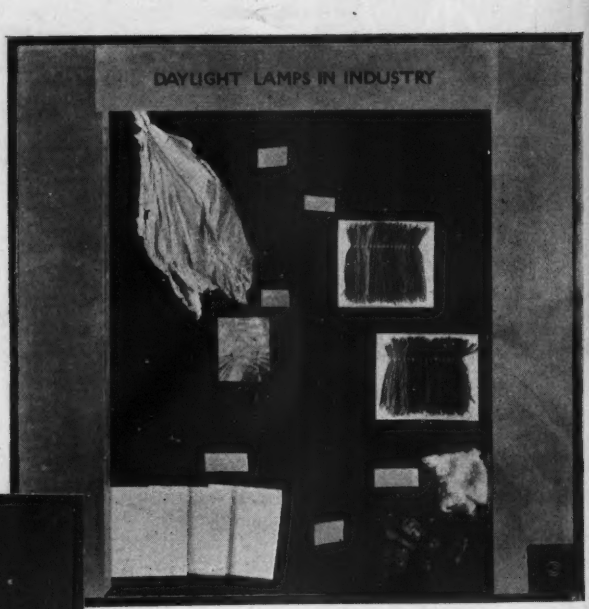

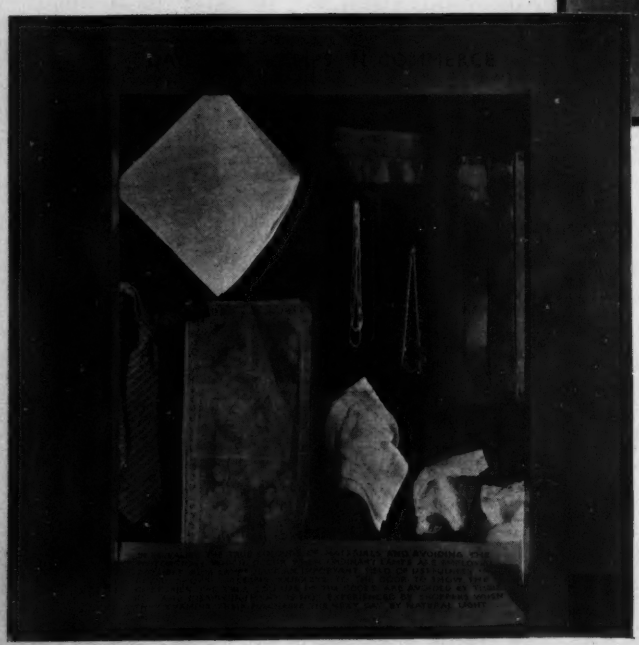

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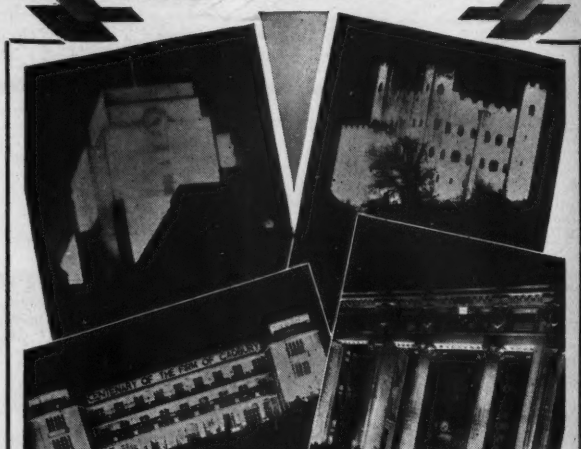

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Road Accidents in England and Wales

WE comment elsewhere (pp. 174-176) on the Report on the above topic, prepared by the Research Department of the National Safety-First Association. At first sight the proportion of night accidents directly attributed to inadequate public lighting (157 out of 1,066) is not apparently very great. It should be noted, however, that an additional 175 accidents occurred at places where there was no artificial light at all—which presumably is even worse than insufficient light! It is also probable that in many other cases the contrast between night and day conditions of visibility played a material but unperceived part. Faults in lighting which would be evident to a lighting engineer might well escape the notice of the layman; further, the artificial light might be relatively "good" in the observer's opinion, and yet so vastly inferior to daylight as to be responsible for mishaps.

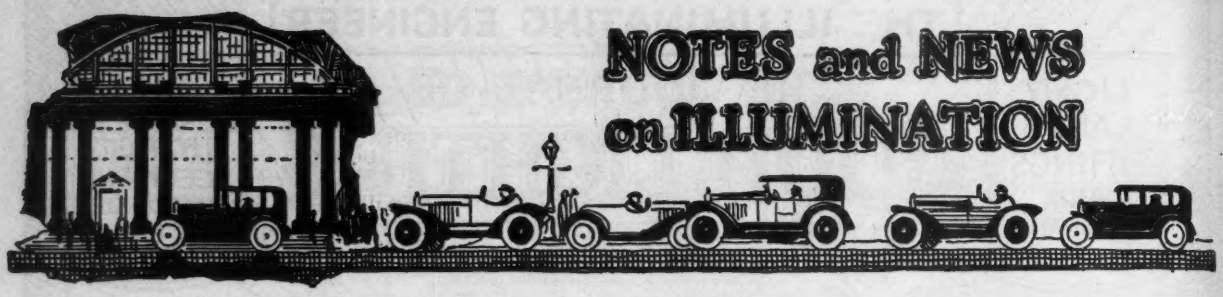
Without a corps of expert observers, therefore, it is difficult to get really satisfying evidence on this particular point. The most fruitful line of reasoning is based on a broad comparison of relative safety by night and by day. It is a remarkable fact, which supports the contention that good street lighting is more vitally important to-day than it ever was, that the ratio of the night accidents to day accidents has been increasing progressively for years. From some statistics for the Metropolitan area analysed by Mr. Gaster,* it would appear that the ratio was about 17 per cent. in 1913. A decade later the same fact was emphasized in the House of Commons by Sir Park Goff, who showed that the ratio had risen from 29 per cent. in 1920 to 46 per cent. in 1926.† The average value derived from the National Safety-First figures, 54 per cent., is higher once again. It can hardly be supposed that during this long period the conditions of driving by night have steadily depreciated; on the contrary they have undoubtedly improved. The obvious inference would appear to be that the roads are being used by night more and more, with the natural result that the proportion of accidents occurring during the hours of darkness tends to rise.

Analysis, however, shows that the relative night and day hazard is greater than appears even from the above figures. Reid and Hinkle, as the result of a survey of accidents in the State of Indiana (U.S.A.), came to the conclusion that "the relative night hazard is four times the day hazard." A complete study on similar lines in this country would involve the correlation of data at present lacking, but there are several modes of analysis that yield instructive conclusions. The first of these methods (applied in our survey in this issue) consists in comparing the number of accidents occurring during certain evening "rush hours," which are light in mid-summer but dark during the winter months. It is surely no coincidence that the number of accidents for this period thus recorded for December is about *twice* that for July. Another method consists in comparing the accident-rate per hour during the hours of darkness with the similar figure for daylight hours—the "dead" hours from 2 a.m. to 5 a.m. being left out of consideration. The ratio naturally varies according to the period of the year and the specific hours that fall within the dark and light periods. But it can be shown that in no case was the night-accident rate less than the day-accident rate, whilst in the month of December (when the periods of light and darkness are respectively equal, if the dead hours are ignored) the accident rate for the night hours is twice that prevailing during the day. If full weight were given to the smaller volume of traffic during hours of darkness, the diminished number of pedestrians using the streets and other relevant factors characteristic of the night period, we might well find that the assumption that "the night hazard is four times the day hazard" also applies in this country.

The broad fact that stands out is that security is much less during the hours of darkness than during the daytime. The cessation of daylight and the substitution of our relatively feeble efforts at artificial illumination affords the obvious explanation. If this is understood it appears futile to suggest, as is sometimes done, that any method of street lighting is "extravagant." All systems of lighting fall far behind daylight. The only question is how much are we to spend in order to approach a little nearer to the relative certainty and security that good daylight illumination confers?

We understand that an official enquiry into the causation of road accidents, on a national basis, is now being conducted. It is to be hoped that the important part played by light in connection with the continually increasing proportion of accidents that occur during the hours of darkness will not be overlooked, and that special efforts will be made to trace the effect both of street lighting and of other applications of light—such as luminous automatic road signals and direction signs—applied in the interests of traffic.

* *Illum. Engineer*, February, 1917, p. 38.
† *Illum. Engineer*, May, 1927, p. 130.



Association of Public Lighting Engineers

TENTH ANNUAL CONFERENCE IN MARGATE.

We understand that a provisional programme of the tenth Annual Meeting and Conference of the Association of Public Lighting Engineers, to be held in Margate during September 4th to 7th, will be circulated shortly. The programme includes a reception and dance on the opening evening, when members and delegates will be the guests of the Mayor and Corporation of Margate. On the following day a luncheon will be given at the Queen's Highcliffe Hotel (the headquarters of the Conference) by the Isle of Thanet Gas Light and Coke Company, and the Association luncheon will take place on the Wednesday. In addition to such usual items as the Presidential Address and the Report of Progress, data on The Lighting of Margate will be presented by Mr. H. V. Emptage. A series of interesting papers has been arranged, including: The Lighting of Seaside Resorts (Mr. W. N. C. Clinch); Electric Discharge Lamps and their Application to Public Lighting (Mr. G. H. Wilson); Street Lighting in the Irish Free State (Mr. F. X. Algar); Public Lighting of Paris (Mr. J. W. Partridge); The Public Lighting of Bombay (Mr. J. P. Blackmore). We are informed that the attendance again promises to break records. Any who desire to attend but have not yet notified the Hon. Secretary (Mr. J. S. Dow, 32, Victoria Street, London, S.W.1), should do so without delay. We may also take this opportunity to repeat our reminder to members to lose no time in sending to the Hon. Editor of the Association (Mr. E. J. Stewart) data for inclusion in the Report on Progress.

National Physical Laboratory

ANNUAL VISIT.

The annual visit to the National Physical Laboratory on June 27th, an enjoyable annual event, afforded once more an opportunity of judging the wide range of work of the Laboratory, which is also illustrated in the Annual Report. We give elsewhere (see p. 177) a summary of those sections of the report bearing on photometry and illumination. Apart from the familiar life-testing of electric lamps, spectrophotometry, and measurement of flux with the 10-ft. integrating sphere, a new mirror apparatus for polar-curve determination was on view in the high-voltage building. Other developments in photometric work include the use of photo-electric cells—a field in which the Laboratory has made considerable progress—the measurement of brightness of radium luminous compound, and the photometry of signal lenses for railway and road traffic. In the illumination building the measurement of illumination in model rooms, and in the adjacent hgh-voltage building researches on the measurement of diffuse reflecting factors, the measurement of particle size in glass, and the testing of rear reflectors for bicycles are in progress. Lastly, we should mention certain researches which are partly photometric and partly physiological, and bear on the behaviour of the eye, now proceeding in the North Lodge. Here such questions as the measurement of eye-sensitivity, the effect of pupil size on luminous efficiency, the determination of thresholds for coloured light by spectroscopic methods, and the time variation of eye-sensitivity to glare are being studied by the aid of somewhat complex and highly ingenious apparatus.

Inadequate School Buildings

One imagines that the joint I.E.S. Committee responsible for the Report on the Natural Lighting of Schools, issued in 1931,* framed their recommendations with full knowledge that they represent what is desired rather than what exists—at all events, in old buildings. It is common knowledge amongst school architects that a very considerable number of schools are exceedingly badly planned in respect of access of daylight, whilst illuminating engineers are well aware that the artificial lighting is often sadly deficient. There are, however, many school buildings far behind even those which we have in mind—as is illustrated in a report presented at a recent conference of the National Union of Teachers in Southampton. *The Daily Express*, in commenting on this matter, recalls that the inspectors in 1925 drew up a "black list" of schools considered unfit for their purpose. It is stated that there remain in use at this moment no fewer than 1,200 of the schools which were thus black-listed. Certainly, the particulars of some schools visited—notably one built in 1841 and condemned twenty years ago—are deplorable. This school building—regarded as the worst in England—is described as a "dank cellar-like place," without adequate heating, lighting or ventilation. The only light is by an oil lamp (though the village is supplied with electricity), and on occasions the teacher has arrived in the winter-time to find the ink frozen in the pots! It is estimated that there are hundreds of schools which should be replaced by modern buildings. The lack of action is ascribed largely to the "economy" in building by local authorities, instituted two years ago. One can only feel that there is something strangely awry with an economic system which permits money to pile up in the banks at a nominal rate of interest when such needs as these go unsatisfied!

Library Buildings: their Heating, Lighting and Decoration

We understand that a book bearing the above title is in course of preparation by the Library Association, and will be issued in the near future. Articles dealing with the Natural Lighting of Libraries (Mr. R. D. Hilton Smith) and the Artificial Lighting of Libraries (Mr. H. Lingard) will be included, and the report on the latter subject issued by the joint committee of the Illuminating Engineering Society and the Library Association in 1931 will be reproduced. Heating, decoration and wall surfaces for libraries are to be dealt with respectively by Mr. S. A. Pitt, Mr. J. P. Lamb and Mr. H. A. Gold, F.R.I.B.A.

* *Illum. Eng.*, July, 1931, p. 155.

Iso-candles for Amateurs

By JOHN W. T. WALSH, M.A. D.Sc.

" What's the good of Mercator's North Poles and Equators,
Tropics, Zones and Meridian Lines?"
So the Bellman would cry: and the crew would reply:
" They are merely conventional signs!"

—*The Hunting of the Snark.*

Introduction.

IN two important papers read before the recent Conference of the Association of Public Lighting Engineers, and reproduced in lengthy abstract in this journal,[1] a considerable amount of use was made of the iso-candle diagram. This comparatively recent addition to the terrors of illuminating engineering made its first really insistent demand for careful consideration when it appeared in Appendix IV of the 1931 edition of the British Standard Specification for Street Lighting. Since then it has shown a tendency to recur at intervals until to-day it is no longer possible to pass it by as one more fad of the "drawing-board" type of lighting engineer, but it must be treated with respect and, as far as possible, with understanding.

The First Step.

The peculiar shape of the iso-candle diagram as usually drawn, a shape which has caused the irreverent to refer to it as the "onion diagram," arises from the fact that no amount of ingenuity will enable the rind of an orange to be flattened out so as to produce a satisfactory orange-peel plate. The iso-candle diagram starts life as the surface of a sphere, and it is this stage in its development which must be described first. The flattening-out process then follows quite simply as a second and absolutely distinct stage in the production of the final diagram.

Let us, then, imagine a source of light to be placed at the centre of a large sphere of clear glass. The word "large" is here used to indicate that the radius of the sphere is so large compared with the dimensions of the source that the latter may legitimately be treated as a "point-source" by an imaginary photometrist[2] situated on the surface of the sphere. To fix our ideas, let us imagine a fly, possessing both a flair for illuminating engineering and a Lilliputian photometer, to crawl over and thereby explore the whole surface of the glass sphere, which we will suppose marked with lines of latitude and longitude for his greater convenience. Let him make a halt at a large number of points on the sphere, and at each of these let him make a measurement of the candle-power of the source of light as viewed from that point. He will naturally record, in any convenient fashion that may occur to him, the candle-power value found at each of his halting-places and so, when his explorations are completed, he will readily be able to pick out *all* the points at which the recorded candle-power has a certain given value, say 500 candles. To draw a continuous line through all these points will then be an easy task, and lo! there is the 500-candle line of the complete iso-candle diagram for the source of light. In a similar manner the line or lines joining *all* the points marked 600 candles will be the 600-candle line, and so on, for as many other values of candle-power as may be desired. When our industrious fly has finished his labours, the sphere will look something like that shown in Fig. 1. The light-source responsible for the curves shown in Fig. 1 is an asymmetric street-lighting fitting—in fact, it is the fitting which Mr. G. H. Wilson chose for Fig. XXXIII of his paper, to which reference was made above.[3] It will be seen that the curves form elongated loops surrounding the point at which our photometric fly would have noted his maximum candle-power reading (about 2,620 candles).

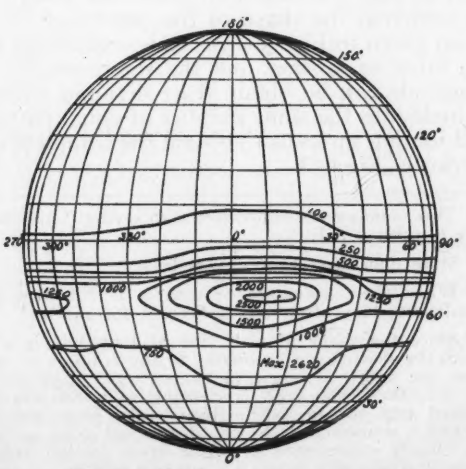


Fig. 1.—The Spherical Surface with Iso-candle Curves.

Flattening the Sphere.

It might, perhaps, be thought that a diagram such as Fig. 1 would suffice for all the purposes for which an iso-candle diagram is needed. A moment's consideration, however, will show that this is not the case. Notice how the portions of the sphere near the edges of the diagram are squashed by comparison with those near the centre. It is the age-old problem of the map-maker over again. No amount of coaxing will make a creaseless covering for a globe out of a sheet of paper, however large (short of infinity) be the number of pieces into which that piece of paper is divided. Similarly, a surface originally spherical cannot be satisfactorily flattened out, however much it may be sub-divided. Distortion there must be, either of shape or area or both, but by the exercise of a vast amount of ingenuity, the map-maker has invented a scheme by which the distortion may be one of shape alone, and not more of that than can be tolerated for our purpose.[4] He calls it the sinusoidal equal-area projection, or sometimes Sanson's or Flamsteed's projection, but we must not allow that to discourage us. All its terrors will vanish when we see how simply it is derived from the original spherical surface.

First let us think of that very useful fruit, the orange, and imagine that the peel covering each of the natural sections (sometimes colloquially referred to as "quarters" for no very obvious reason) has been removed separately and entire. If these portions of peel are placed side by side as shown in Fig. 2 they can be flattened out without *much* distortion of either shape or area. Their edges, however, refuse to fit together, and it is at this stage that the distortion of shape occurs. Let us confine our attention for the moment to the two central sections,

[1] F. C. Smith, *Illum. Eng.*, Nov., 1932, p. 287.
G. H. Wilson, *Illum. Eng.*, Nov., 1932, p. 292.

[2] "Photometric practitioner" might possibly be more orthodox, but it would certainly be more cumbrous.

[3] Fig. 7 in the Abstract published in this Journal.

[4] The curious in these matters may profitably consult the article on "Map Projections" in the "Encyclopædia Britannica," or one of the several learned works which have been published on this subject, such as R. K. Melluish's "Introduction to the Mathematics of Map Projections" (C.U.P., 1932).

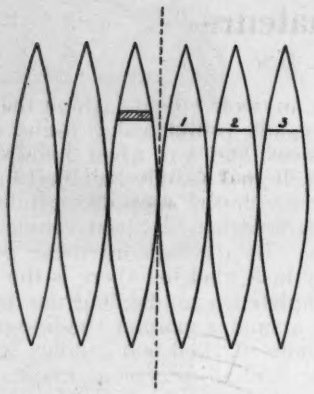


FIG. 2.—The Strips of Spherical Surface.

one on each side of the vertical line of symmetry (shown dotted). If it be supposed that this particular orange peel has the special property that any portion of it can be shifted *horizontally* with respect to the contiguous portions without rupture, we may distort each of the two sections by means of such horizontal displacements until the inner edge of each section touches the central line of symmetry. The result is shown in Fig. 3 (*a*). It will be clear that, although there is a distortion of the shape of each piece of orange-peel, there is no distortion of area, and this statement is true, not only of each section as a whole but of any element of a section. For example, the area shown shaded in Fig. 3 is precisely equal to that shown shaded in Fig. 2, although the shape has been somewhat altered in that one of the sides is now vertical while the other slopes more than it did originally. If an exactly similar process be applied to the other sections shown in Fig. 2, we get the state of affairs exhibited in Fig. 3 (*b*).

The hypercritical may object that as long as each section of peel has a finite breadth it cannot be flattened out as was supposed above. To this objection the mathematician, for whom such criticisms hold no terrors, replies "divide each section into an infinite number of similarly shaped sections of infinitesimal breadth and then apply to these sub-sections the process which has just been described." The result will be precisely that shown in Fig. 3.

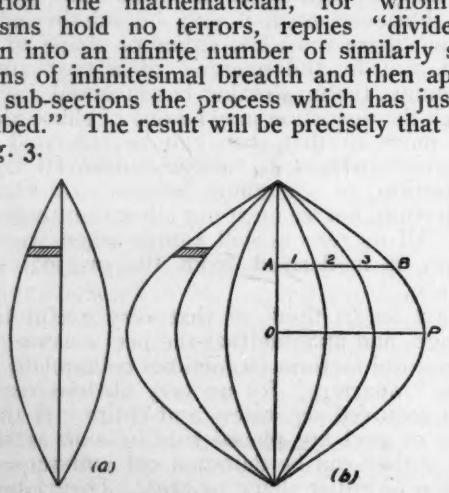


FIG. 3.—The Strips distorted so as to fit together.

THE ANGLE NETWORK.

Just as an ordinary polar curve of light-distribution would be very incomplete without its system of radial lines to indicate angles measured from the downward vertical, so the iso-candle diagram must needs have a network of lines to indicate angles of latitude and longitude (to return to the map-maker's terminology). As we all know, lines of latitude are spaced equally on the sphere, i.e., if you travel along any line of longitude, the distance from latitude 49° to latitude 50° is precisely the same as the distance from 89° to the pole. It follows from this, and from the manner in which Fig. 3 (*b*) was obtained, that lines of latitude on the sinusoidal diagram are likewise spaced at equal intervals from nadir to zenith.[5]

What, now, of the lines of longitude? These lines have suffered somewhat severely by the horizontal displacements necessary in order to convert Fig. 2 into Fig. 3 (*b*). It is, however, fairly easy to determine their shape if we remember that the horizontal movement made was one of *position* only, and did not involve any change of *length*. The length of the line AB in Fig. 3 (*b*) therefore is equal to the total length of the lines marked "1," "2," "3" in Fig. 2. If both these diagrams represent a *hemisphere*, and not the whole sphere, the length AB is equal to one-quarter of the total length of the line of latitude to which it corresponds. We can find this length at once from the diagram of Fig. 4; it is clearly the circumference of the circle of which AM is the radius, just as the equator is the circumference of the circle whose radius is OL, the radius of the sphere. Thus the length AB in Fig. 3 bears the same ratio to OP as the length AM in Fig. 4

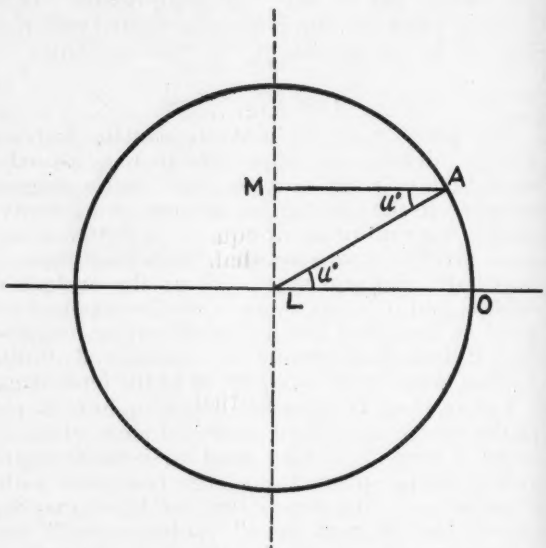


FIG. 4.—Finding the length of AB in Fig. 3. AM=OL×cos $u°$.

bears to OL. This ratio has been calculated, and is given in books of mathematical tables for all values of the angle ALO; the table is called a table of cosines because mathematicians have, for a very long time past,[6] referred to this ratio as a "cosine."[7] Thus the length of any such line as AB is equal to OP × cos $u°$ where AB represents the line of latitude u degrees measured from the equator, or $(90+u)$ degrees measured from the nadir. It will be seen that the shape of the outer line of the diagram given in Fig. 3 (*b*) is thus completely fixed by the table of cosines and the intermediate lines of longitude can be obtained by dividing each line of latitude into the same number of equal parts (say 9) and joining up so as to obtain the complete diagram shown in Fig. 5.[8]

[5] This sounds more impressive than saying "from the bottom pole to the top pole."

[6] More than three centuries at least.

[7] When their acquaintance with it is sufficient to justify familiarity, they often call it "cos" for short.

[8] Since the shape of each line of longitude is a curve in which the abscissa corresponding to any ordinate $u°$ (measured from the nadir) is equal to cos $(u-90)°$, and therefore to sin $u°$—the cosine and sine being two different ratios so defined that cos $(u-90)° = \sin u°$—the projection has been dubbed "sinusoidal." Since, also, equal areas on the sphere are clearly represented by equal areas on the diagram, the name "sinusoidal equal-area projection" has unfortunately emerged.

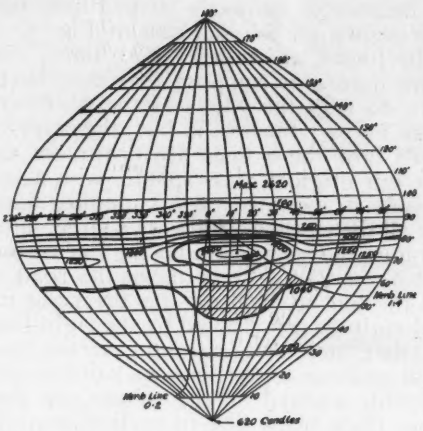


FIG. 5.—The Final Iso-candle Diagram.

This diagram has had added to it the iso-candle lines shown in Fig. 1. It will be noticed that their shape is somewhat different in the two figures, except near the central part of the diagram. From what has been said above it will be clear that although the curves of Fig. 5 have not exactly the same shape as the curves on the sphere which they represent, yet the area which is enclosed between any pair of them is exactly equal to the area enclosed between the two corresponding curves on the sphere, assuming that the area of the whole diagram of Fig. 5 is made equal to half the area of the sphere. This, as we shall see presently, is a most important fact.

PRACTICAL APPLICATIONS.

We now come to the practical uses which can be made of a diagram such as that in Fig. 5. In the first place, it can be used in exactly the same way as an ordinary polar curve is used in the case of a light-source with a symmetrical candle-power distribution, viz., to find the candle-power of the source in any given direction. For example, the candle-power at an angle of 25° below the horizontal (i.e., 65° from the downward vertical or nadir) and 15° right of the plane chosen as the plane of zero azimuth, is 1,400 candles.

If it be desired, a polar curve can be constructed for any given azimuthal plane, for instance the 15° plane right already mentioned. All that is necessary is to chose any convenient points on the 15° line of longitude and to tabulate the corresponding values of (*a*) angles from the nadir, and (*b*) candle-powers, as follows:—

Angle	Candle-power
0	620
29	750
46	1,000
62	1,250
67	1,500
72	2,000
74	2,500
75	2,600
76	2,500
79	2,000
82	1,500
83	1,250
84	1,000
87	500
89	250
98	100
107	50

These values, when plotted, give the desired polar diagram of candle-power distribution for the source in the given plane, as shown in Fig. 6. It will be seen that any number of such diagrams may be constructed from Fig. 5 for other vertical planes. The diagram for the plane 60° right is also shown in Fig. 6.

A very important feature of the iso-candle diagram is the ease with which it can be used to calculate the total luminous flux which the light-source emits within any given solid angle. First we must recall that candle-power may be (and has been) defined as solid angular flux density. This statement is more likely to confuse than to enlighten, and the customary procedure[9] is to think of a source of light placed at the centre of a sphere,

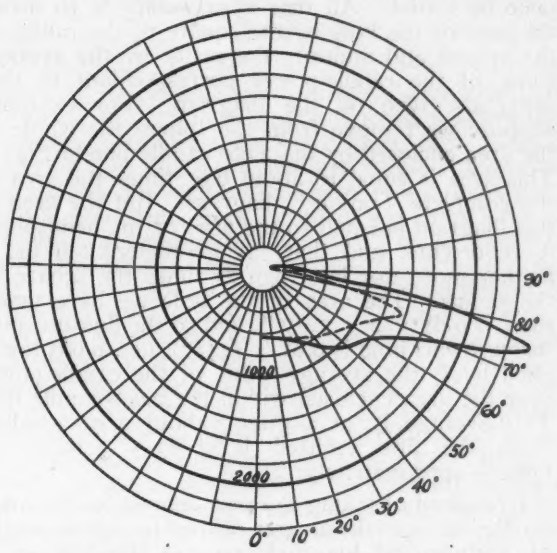


FIG. 6.—The Polar Curves at 15° azimuth (full line) and at 60° azimuth (broken line).

as shown in Fig. 7, and to imagine that the candle-power of this source is one candle *in all directions*. The next step is to cut away from the sphere a portion having an area equal to the square of the radius. Thus, if the radius of the sphere is one foot, we cut out a piece having an area of one square foot; if the radius is two feet the area of the piece we remove is four square feet, and so on. All that the definition teaches us really is that the luminous flux escaping from the sphere under these conditions is one lumen. Clearly, if the candle-power of the source

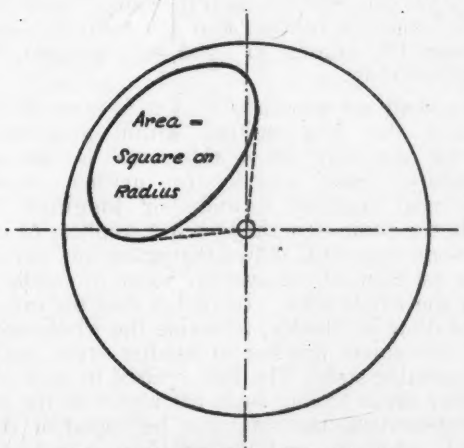


FIG. 7.—The Definition of the Lumen.

[9] "What does Crustimoney Proseedcake mean?" said Pooh.
"For I am a Bear of Very Little Brain, and long words Bother me."
"It means the Thing to Do."
"As long as it means that, I don't mind," said Pooh humbly.
—*Winnie-the-Pooh.*

is not one candle, but I candles, the flux escaping through the hole is I lumens. Now it stands to reason that, since the light-source is perfectly uniform, the amount of luminous flux coming out of the hole must be proportional to the area of the hole. If this is n times the square on the radius of the sphere the flux escaping is nI.

Now if we look upon an iso-candle diagram, like that of Fig. 5, as representing a sphere (or, more precisely, a hemisphere) surrounding a source of light, we shall see at once that the flux which would escape from any given hole in the sphere can at once be found. All that is necessary is to divide the area of the hole by the square of the radius of the sphere and multiply the result by the average value of the candle-power corresponding to that area, as given on the diagram. For example, suppose we remove from the sphere the whole of the area enclosed by the 2,000-candle line in Fig. 5. This area is equal to about 0.01 times the area of the complete "onion" diagram. But the area of this diagram is equal to the area of the hemisphere it represents, and that, as geometers tell us, is neither more nor less than 2π times the square on the radius. The area of the hole we have made, then, is $0.01 \times 2 \times 22/7$ [10], and so the flux escaping through this hole is $0.01 \times (44/7)$, i.e., 0.063 multiplied by I, the average value of the candle-power over the area enclosed within the 2,000-candle line. This average is, at a guess, about 2,250 candles. Thus the flux emitted is $0.063 \times 2{,}250 = 124$ lumens approximately.

If, instead of taking the area defined by the 2,000-candle line, we take an area defined by certain angles of latitude and longitude we get the number of lumens emitted by the source within the corresponding angular limits. For instance, let us find the number of lumens emitted at all angles between 30° and 60° from the downward vertical. The area of this part of the diagram is equal to about 0.18 of that of the whole onion diagram, i.e., $0.18 \times (44/7) = 1.13$ times the square of the radius of the sphere. The average value of the candle-power within this region seems to be about 850, so we may say that the flux emitted by the source between the angles 30° and 60°, on one side (for the diagram represents one hemisphere only, and not both) is $1.13 \times 850 = 960$ lumens. If the source is a symmetrical one, so that we may assume that the flux emitted in one hemisphere is the same as that emitted in the other, it follows that the total flux emitted between the angles 30° and 60° is 1,920 lumens approximately.

We shall see presently that it is often necessary to find the flux emitted within a given area of the diagram when this area is defined by boundary lines which are neither iso-candle lines nor lines of latitude or longitude. Precisely the same general principle applies, of course, but sometimes it is difficult to make any reasonably close estimate of the average value of candle-power over the whole area. In such a case the only thing to be done is, clearly, to divide the whole area into any convenient number of smaller areas, each of a manageable size. The flux emitted in each of these smaller areas having been calculated in the manner just described, the total can be found at once by simple addition, and the problem is solved. We shall have an example of this process when we come to consider a very important practical problem in street lighting.

Kerb Lines.

In Appendix IV of the Street Lighting Specification, and in one of the figures in Mr. Wilson's paper already referred to, we shall find an onion diagram with a number of curiously shaped lines on it like the pair shown on the diagram of Fig. 5. These, it will be found, are called "kerb lines," and it is therefore natural to suppose that they have something to do with the edges of the roadway, often known as kerbs. Such is, in fact, the case.

To see how these lines are drawn let us again imagine our original glass sphere, with a source of light inside it, mounted on a lamp-post and set up just for all the world as if it were a street lamp. We will arrange the sphere so that the line of longitude marked 0° in Fig. 1 faces down the road towards us and the line marked 90° on the right (i.e., the line of longitude represented by the right-hand edge of the diagram) faces straight across the road. Then, in addition to the lines of latitude and longitude already marked on the sphere, we may draw a further thick black line of such a shape that the shadow cast by it falls precisely along one of the kerbs at the edge of the roadway. This new line on the sphere is a "kerb-line" of the iso-candle diagram.

If the kerb is a straight one (and illuminating engineers, like others, are rather prone to make simplifying assumptions such as this), a moment's thought will show that the kerb line on a diagram such as that of Fig. 1 is a straight line.[11] On the onion diagram, however, the shape is slightly altered, especially at the part near the edge of the diagram, and the kerb line has the form shown in Fig. 5. The two particular lines drawn there are respectively the kerb lines for kerb distance ratios of 0.2 and 1.4, i.e., when the distances of the foot of the post from the kerbs are, respectively, 0.2 and 1.4 times the height of the light-source above the roadway. For instance, if the mounting height of the lamps is 15 feet and the foot of the lamp-post is 21 ft. from the kerb on the opposite side of the road, the kerb distance ratio is $21/15 = 1.4$ times the mounting height, and the approximate kerb line on the iso-candle diagram is the line marked "kerb-line 1.4." Similarly if the lamp is overhung 3 ft., and is 15 ft. above the roadway, the kerb distance is $3/15 = 0.2$ times the mounting height and the appropriate kerb-line on the iso-candle diagram is that marked "kerb-line 0.2" in Fig. 5.

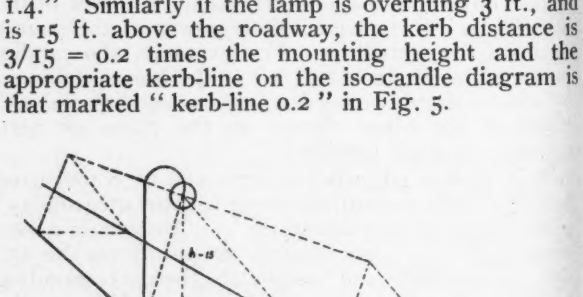


Fig. 8.—How the Kerb Lines are obtained.

The diagram of Fig. 8 will make matters quite clear, and from this it will be seen that the only luminous flux which reaches the street is that

[10] Little Jack Horner
Sat in a corner
Finding the value of π.
He cried 22
Over 7 will do,
For no mathematician am I.

[11] It is obviously what geometers and navigators call a "great circle," since it is the intersection of the sphere with a plane passing through its centre, viz., the plane containing both the kerb and the light-source.

emitted by the light-source within the region defined on the iso-candle diagram by the two kerb-lines corresponding to the edges of the roadway under the conditions of mounting actually adopted. All the flux emitted outside these limits either falls on the footway or on the buildings at the sides of the street or else is sent skywards instead of earthwards.

Finding Average Illumination.

It is often desired to calculate the average illumination of the roadway which may be expected from a given street-lighting installation, and this calculation is a fairly simple one, given (i) the iso-candle diagram for the type of street lamp used and (ii) the dimensions of the roadway, the mounting height of the lamps and the position of each lamp on plan.

The method will be seen most clearly by following out the calculations in a typical case. Let us suppose that the iso-candle diagram of each lamp is that shown in Fig. 5. Let the width of the street be 40 ft. and the mounting height of the lamps 25 ft. Further, let the lamps be supported on brackets so that they overhang the near kerb by 5 ft.; the distance of the far kerb from the point directly below a lamp will thus be 35 ft. Let the spacing-height ratio be 7, so that the lamps are spaced $7 \times 25 = 175$ ft. apart.

The two kerb-lines appropriate to these conditions are those shown in Fig. 5, since $5/25 = 0.2$ and $35/25 = 1.4$.[12] It follows that all the flux emitted by the lamp within the area bounded by these two lines on the iso-candle diagram reaches the street, and a moment's reflection will show that twice this amount of flux reaches the roadway *per 175 ft. run*, for there is one lamp every 175 ft. and each lamp sheds twice this amount of flux on the roadway. In other words, if this amount of flux be F, the amount reaching the roadway per square foot will be, *on the average*, $2F/(175 \times 40)$ lumens. Since an illumination of one foot-candle is the result of having one lumen of flux evenly distributed over a surface one square foot in area, it follows that the *average* illumination of the roadway will be $2F/(175 \times 40)$ foot-candles. It now remains to calculate F.

It is practically impossible to estimate the average candle-power over the whole area enclosed by the kerb-lines, so the best thing to do is to divide this area into a number of smaller areas, as already suggested. Let us take as our partial areas the portions of the diagram bounded by the kerb-lines and a pair of successive iso-candle lines. For instance, take the area shown shaded in Fig. 5. The area of this, expressed as a fraction of the area of the whole diagram, is 0.0315. The average candle-power clearly lies between 1,000 and 1,250. Hence the flux emitted within this shaded area lies between $0.0315 \times (44/7) \times 1{,}000 = 198$ and $0.0315 \times (44/7) \times 1{,}250 = 248$ lumens. It will be seen that the total area between the kerb-lines may be divided into eleven partial areas of the same kind as that shown shaded, and the luminous flux emitted within each may be estimated as lying between the limits tabulated below:—

Upper limit			Lower limit		
0·001	× 500	= —	0·001	× 250	= —
0·004	× 1,000	= 4	0·004	× 500	= 2
0·002	× 1,250	= 2	0·002	× 1,000	= 2
0·003	× 1,500	= 5	0·003	× 1,250	= 4
0·011	× 2,000	= 22	0·011	× 1,500	= 17
0·048	× 2,620	= 126	0·048	× 2,000	= 96
0·042	× 2,000	= 84	0·042	× 1,500	= 63
0·046	× 1,500	= 69	0·046	× 1,250	= 58
0·198	× 1,250	= 248	0·198	× 1,000	= 198
0·450	× 1,000	= 450	0·450	× 750	= 338
0·291	× 750	= 218	0·291	× 620	= 180
Sum (max.)		1,228	Sum (min.)		958

The areas by which the candle-powers have been multiplied in the above table are all expressed as fractions of the area of the whole diagram and multiplied by 2π (i.e., 44/7), so that the sums represent luminous flux in lumens.

The maximum value of the total flux does not differ from the minimum value by more than 25 per cent., and it is therefore safe to take a value halfway between the two sums as a close enough approximation to the total flux F;[13] in other words, F = 1,093 lumens. The average illumination of the roadway is thus equal to 0.31 foot-candle.

Calculating the Illumination at a Point.

A much simpler problem which can easily be solved by the aid of an iso-candle diagram is that of finding the illumination at any given point in the roadway. All that is necessary is to draw a scale plan of a portion of the roadway, and mark on this the correct positions of the base of the lamp-post (or the point directly underneath the lamp) and of the point in question, as shown in Fig. 9, where L and P represents these two points respectively. The line LP is produced to cut the kerb line and the angle at the intersection is measured. This is clearly the angle of longitude on the iso-candle diagram. A line is then drawn through L, perpendicular to LP and of a length representing the height of the lamp above the roadway (of course, to the same scale as that used for the plan). This line is LA in Fig. 9. The line AP is drawn and the angle LAP is measured. This is the angle of latitude on the iso-candle diagram. Using the angles shown in Fig. 9, viz., 15° and 77.5°, we find from Fig. 5 that the candle-power corresponding to these angles is 2,250. It follows that this is the candle-power of the source in the direction of P. The illumination at P, then, is equal to this candle-power, divided by the square of the distance AP, and multiplied by the cosine of the angle of incidence of the light at P. This cosine is equal to AL/AP (see footnote on p. 120), and thus the ilumination at $P = 2{,}250 \times AL \div AP^3$. To save measuring AP we can re-write this formula thus: $2{,}250 \times (AL/AP)^3 \div AL^2$, and since AL/AP is equal to the cosine of the angle LAP, while AL is the mounting height, this expression is equal to

$$\frac{2{,}250 \times (\text{cosine LAP})^3}{(\text{mounting height})^2} = 2{,}250\ (0.216)^3/18^2 = 0.07$$

foot-candle. This, of course, is the illumination at P due to the light from L alone. If there is another lamp contributing an appreciable amount of light to P, a similar calculation is necessary to find the illumination due to this second lamp, and then the two figures are added together to give the total illumination at P.

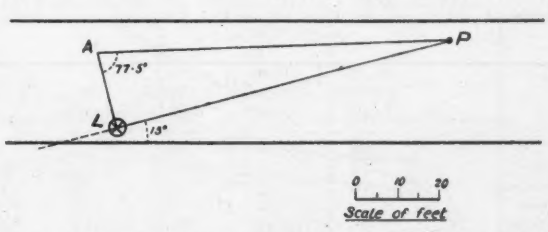


Fig. 9.—Calculating the Illumination at a point L=the lamp; P=the point.

[12] Kerb lines for other ratios are given in the Street Lighting Specification and in Mr. Wilson's paper.

[13] The Street Lighting Specification allows a difference of not more than 20 per cent. between the maximum and the minimum. This would require iso-candle lines to be drawn on the diagram at rather closer intervals, with a corresponding increase in the number of partial areas, but the above example serves quite well to illustrate the method.

A Statistical Review of Street Accidents

THE informative review recently issued by the National Safety-First Association* covers a period of six months, July-December, 1932. The arrangements for this enquiry were supervised by a committee on which fifteen bodies were represented, the first two on the list being the Ministry of Transport and the Association of Public Lighting Engineers. It is understood that this enquiry, which covered the last six months of 1932 only and is now terminated, has been superseded by an official national enquiry conducted under the Ministry of Transport.

The present investigation relates only to *fatal* accidents, of which 3,129 are reported. The chief source of information has been the inquests conducted on fatal accidents in England and Wales (there are no inquests in Scotland), and it is believed that 95 per cent. of fatal accidents that have occurred have been included.

A map accompanying the report shows the distribution of accidents throughout England and Wales. Naturally, the greatest number occurred in the vicinity of the larger cities, 689 persons being killed during the half-year within the boundaries of Greater London alone.

The above total of deaths corresponds to an average of 16 to 17 a day. Apparently the worst daily average (23) occurred on Saturdays, but the maximum number recorded (36) was on Christmas Eve.

The accidents and relevant data are classified in various ways. Before dealing more specifically with those tables that have a direct relation to lighting we may refer to several points of general interest. Accidents were classified in terms of the vehicles involved. Over 90 per cent. were distributed amongst motor cyclists, pedal cyclists and pedestrians. Nearly half the total accidents (i.e., 48.6 per cent.) were suffered by pedestrians. There is, however, one very singular point—the relative risk of motorist and pedestrian is apparently seasonable. Thus, during November and December the number of pedestrians killed was 2½ times as great as the number of motorists; yet during July and August more motorists than pedestrians were killed. Tables relating to age of victims suggest that, as one might expect, it is the very young and the very old that are most vulnerable. Other conclusions are that 86 per cent. of accidents involve the human element; 89 per cent. of accidents occur when there is no considerable volume of traffic; the proportion of accidents occurring in towns built over districts and open country was approximately in the proportions 2 : 1 : 1—i.e., about 25 per cent of accidents occur in open country.

LIGHTING CONDITIONS IN THE CASES OF ACCIDENTS WHICH OCCURRED DURING HOURS OF DARKNESS (TABLE XIIIB IN THE REPORT.)

	Good Artificial Light.	Poor Artificial Light.	No Artificial Light.	Not Specified.	TOTAL.
July	14	8	16	29	67
August	20	7	32	55	114
September	19	25	33	70	147
October	23	31	28	131	213
November	26	41	17	154	238
December	28	45	49	165	287
TOTAL (6 months)	130	157	175	604	1,066
Percentage	12·2	14·73	16·41	56·66	100

The two tables in the report which bear most directly on artificial lighting are VIIA (vehicular defects contributing to accidents) and XIIIB, in which conditions of public lighting in the street at the moment when the accident occurred are analysed in general terms.

In Table VIIA eight vehicular defects, regarded as contributing to accidents, are classified. It is surely significant that, out of a total of 374 accidents thus treated, 88 were due to dazzle lights and 117 to ineffective lighting of vehicles. Even such an important condition as defective brakes was responsible for only 59 fatalities—less than a third of those associated with unsatisfactory vehicle lights.

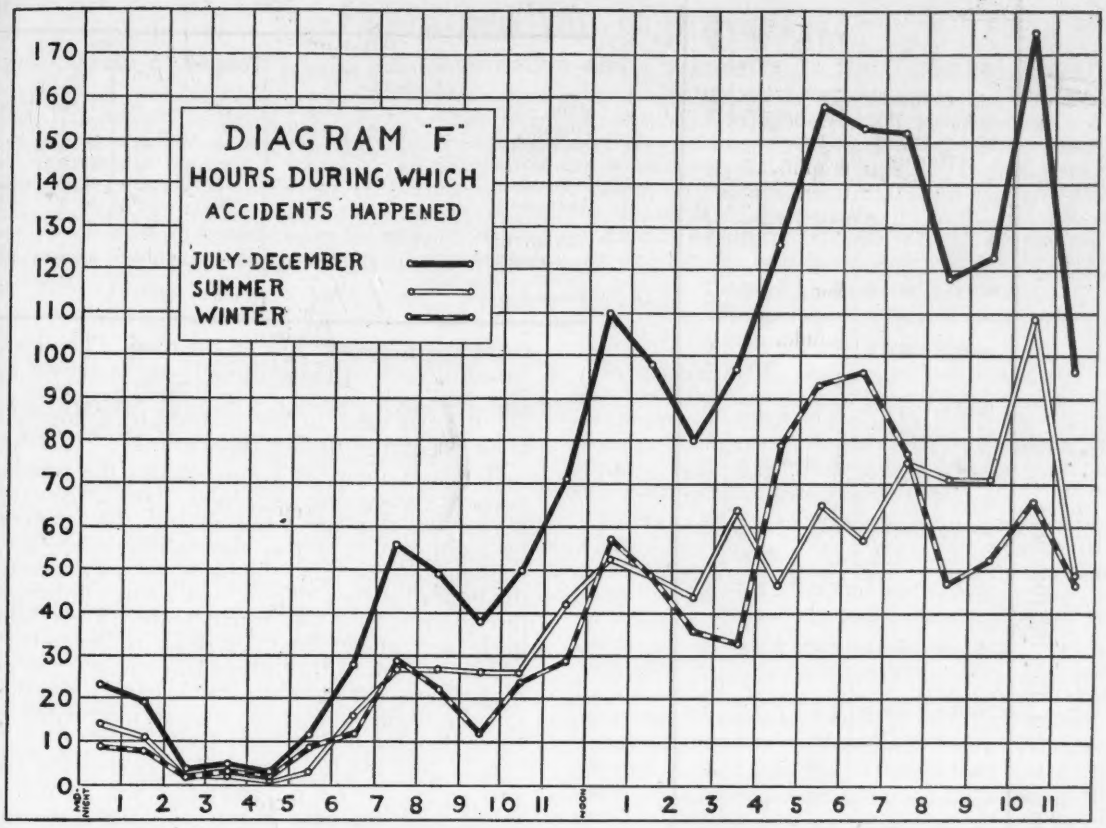
Table XIIIB represents an attempt to classify under four headings ["Good artificial light," "Poor artificial light," "No artificial light," and "Not specified"] the conditions prevailing in the case of 1,066 accidents that occurred during the hours of darkness. From these data it appears that poor lighting was judged to be a contributory cause in 157 out of 1,066 cases which occurred during the hours of darkness, i.e., 14.7 per cent., or 5 per cent. of all accidents. But it will be observed that in 175 other cases there was *no* artificial light (so that the actual lighting conditions might well be regarded as even less satisfactory than those recorded above!), and that the remaining cases in which no reference was made to lighting totalled 604—nearly 60 per cent. of the total. Only in 130 cases (12.2 per cent.) was the lighting definitely referred to as good. When one recalls how difficult it is to secure a good judgment of lighting conditions from untechnical observers, and how little importance the average man may attach to faults that would strike a lighting engineer as evident, one may safely infer that the proportion of accidents in which either public lighting or vehicle lighting are contributory causes of accidents is very considerable.

We come last to Tables VIII and XIIIA, in which accidents are tabulated according to the month, and are also divided into those occurring respectively by night and by day. It is interesting to observe (from Table VIII) that the most fatal period in each month was 10 p.m. to 11 p.m., whilst in the later months of earlier darkness the most dangerous hour was 6 to 7 p.m. in October and 5 to 6 p.m. in November and December. As might be expected, the proportion of accidents occurring at night rises steadily, as winter approaches, from 14.3 per cent. in July to 54.46 per cent. in December. The average for the half-year was 35.19 per cent.

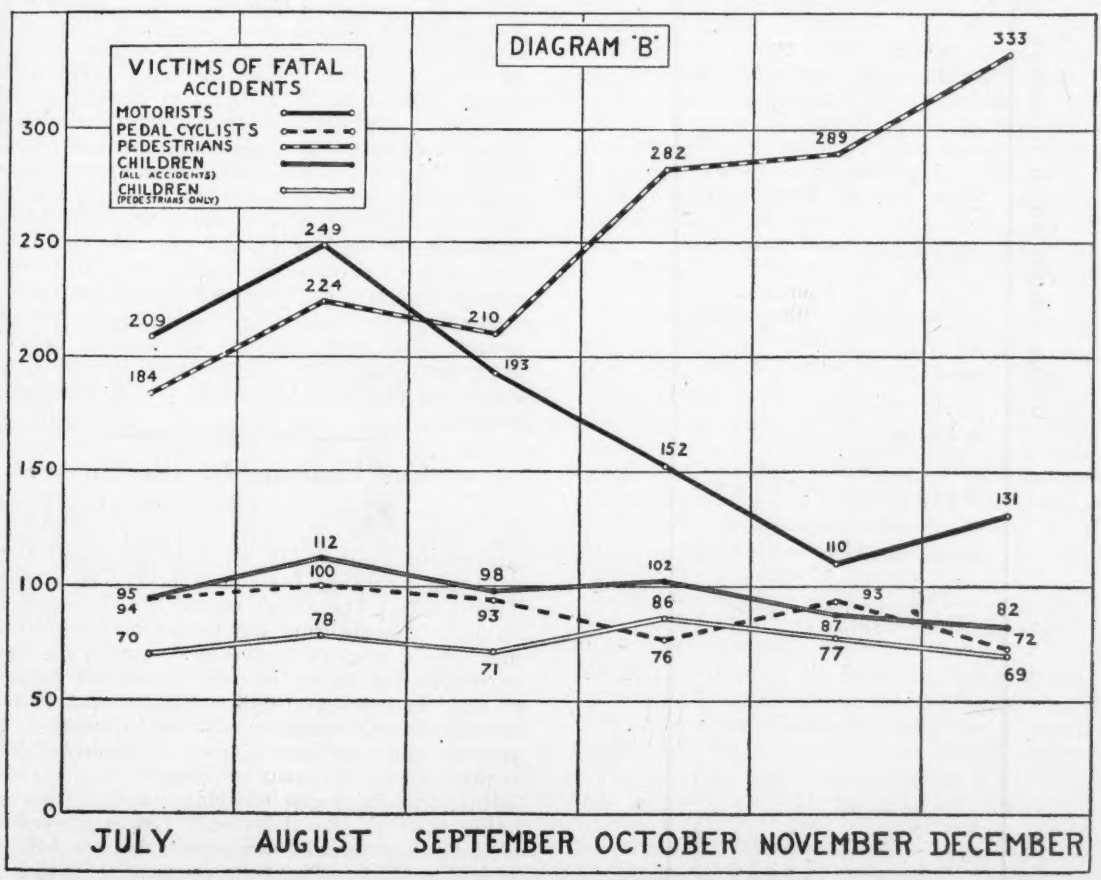
This proportion certainly seems a very high one, when one bears in mind that (*a*), on the whole, by far the greater part of driving still takes place during daylight hours and that (*b*) during a great section of the night hours there is very little traffic, and very few pedestrians using the streets.

The relative accident rate by night and by day is, however, really much less favourable to the night period than the above figures, quoted from the Report, would suggest. By examining the tabulation of accidents hour by hour (Table VIII in the Report) and comparing with a sunset and sunrise table for 1932, one can form a rough idea as to which hours should be regarded respectively as "dark" and "light." If, in addition, we agree to rule out the three dead hours from 2 a.m. to 5 a.m., and consider only the remaining hours, we get a much fairer basis of comparison. (During this period of three hours there is little vehicular traffic, and certainly

* "A Statistical Review of the Facts and Circumstances of Fatal Road Accidents in England and Wales during the six months, July to December, 1932." Price 2s. 6d. (with map); obtainable from the National Safety-First Association, Terminal House, 52, Grosvenor Gardens, London, S.W.1.



A Diagram showing the distribution of accidents per hour. A significant point is that winter curve crosses the summer curve during the rush period (4 p.m. to 7-30 p.m.). During this period accidents are much more numerous during the winter months when darkness prevails. On the other hand, the reverse applies to the latter period (7-30 to 11-30)—possibly because these hours are so much more used for pleasure-driving during the summer-time.



A Diagram illustrating the comparative numbers of accidents to pedestrians, motorists, etc., throughout the half-year. (Note the remarkable contrast in the apparent risks to motorists and pedestrians in summer and winter.)

HOURS DURING WHICH ACCIDENTS OCCURED. (TABLE VIII. IN THE REPORT.)

	Midnight—1 a.m.	1 a.m.—2 a.m.	2 a.m.—3 a.m.	3 a.m.—4 a.m.	4 a.m.—5 a.m.	5 a.m.—6 a.m.	6 a.m.—7 a.m.	7 a.m.—8 a.m.	8 a.m.—9 a.m.	9 a.m.—10 a.m.	10 a.m.—11 a.m.	11 a.m.—Noon.	Noon—1 p.m.	1 p.m.—2 p.m.	2 p.m.—3 p.m.	3 p.m.—4 p.m.	4 p.m.—5 p.m.	5 p.m.—6 p.m.	6 p.m.—7 p.m.	7 p.m.—8 p.m.	8 p.m.—9 p.m.	9 p.m.—10 p.m.	10 p.m.—11 p.m.	11 p.m.—Midnight.	Not Specified.	Total.
July	2	5	1	—	1	2	6	9	7	13	10	14	21	21	12	15	16	20	17	26	16	23	36	12	165	470
August	7	3	1	1	—	1	9	14	14	5	13	16	18	15	19	27	17	26	23	21	27	27	39	22	190	555
September	5	3	—	1	—	—	1	4	6	8	3	12	14	13	13	22	14	19	17	28	28	21	34	15	201	482
October	4	4	—	1	—	6	3	6	6	6	11	7	13	19	11	11	13	18	38	26	11	16	21	16	233	500
November	3	1	—	—	1	—	3	11	11	2	9	8	26	16	12	10	32	34	28	22	21	15	22	12	196	495
December	2	3	2	2	1	3	6	12	5	4	4	14	18	14	13	12	34	41	30	29	15	21	23	19	200	527
Total	23	19	4	5	3	12	28	56	49	38	50	71	110	98	80	97	126	158	153	152	118	123	175	96	1,185	3,029

LIGHTING CONDITIONS. (TABLE XIIIA IN THE REPORT).

	Daylight.		Twilight.	Dark.		Total.
	Dazzling Sunlight.	Ordinary.		No.	%	
July	1	375	27	67	14·3	470
August ..	5	416	20	114	20·5	555
September ..	4	305	26	147	30·5	482
October ..	3	274	10	213	42·6	500
November ..	1	244	12	238	48·08	495
December ..	—	220	20	287	54·46	527
Total (6 months) ..	14	1,834	115	1,066	35·19	3,029
Percentage ..	·46	60·55	3·8	35·19		100

there are no pedestrians on the road. The insignificance of each of these three hours is shown by the fact that only four, five and three accidents—only about ½ per cent. of the total night accidents tabulated—occurred during this period.)

If this is done, and one studies the number of accidents occurring per hour, one arrives at the interesting conclusion that in July the accident-rate by night and by day is almost the same—notwithstanding the fact that the night period covered only the hours between 10 p.m. and 2 a.m.; in September the accident rate was found to be 16 per hour by night and 13 per hour by day; in December (for which, excluding the agreed three hours, the period of darkness and light are almost equal), the accident rate by night was about 21 per hour—just about *twice* that for the daylight hours.

It is also surely striking that during the periods 4 to 5 p.m., 5 to 6 p.m., and 6 to 7 p.m., which correspond with the rush hours, and therefore furnish the best test of the relation between lighting conditions and security, the number of recorded fatal accidents is in each case almost exactly twice as great in December as in July. This difference must surely be ascribed mainly to the fact that good daylight prevails during these hours in July, whereas in December they form almost completely a period of darkness. The results therefore seem to afford a clear indication of the greater hazard of driving by night, especially as statistical data included in the Report suggest that weather (the other chief condition that varies with the seasons) exercises but little influence on the accident rate. There are, moreover, one or two circumstances which lead to minimize the night-rate, for example the fact that these statistics relate to both towns and country; so that "rush-hour" data are somewhat masked by data referring to country roads, where this phenomenon does not occur. If similar data were assembled for large towns only the comparative results in July and December might be even more marked.

Car Lighting by Electricity

At a recent meeting of the Illuminating Engineering Society of Australia a paper on the above subject was read by Mr. B. A. Giles (Superintendent of Train Lighting for the N.S.W. Department of Transport). The paper traced the development of modern train-lighting equipment and described the methods at present in use in Australia for lighting carriages and vans. In order to enable passengers to read in comfort an illumination of 4 to 6 foot-candles is considered desirable, whilst in postal sorting vans 12 foot-candles is furnished on the reading plane. The development of electric headlights, for which chrome-plated reflectors are now being used, is also dealt with. It is interesting to observe that breakdown-vans are now being furnished with floodlighting equipment, which must prove of considerable value in dealing with accidents on lonely parts of the line.

Literature on Lighting

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. L. J. Collier, Mr. H. M. Cotterill, Mr. J. S. Dow, Mr. J. Eck, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. W. R. Stevens, Mr. J. M. Waldram, Mr. W. C. M. Whittle, and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—ED.

(*Continued from p. 162, June, 1933.*)

II.—PHOTOMETRY.

177. The National Physical Laboratory Report for the year 1932.

(*H.M. Stationery Office.*)

PHOTOMETRY DIVISION (*pp.* 137-139.)

Photo-electric Photometry.—The ultimate aims of research on photo-electric photometry, as stated in the report, are: (1) to develop photometers which can be used in place of visual photometers, with the advantage of greatly increased speed of working, while maintaining the desired accuracy for commercial tests; and (2) to develop a type of photo-electric photometer which may be used for standardization purposes possibly to a greater precision than can be realized visually. To meet these requirements a thermionic-bridge photometer has been developed for (1) and an electrometer photometer for (2). Attention has been concentrated on various sources of error affecting the performance of photo-electric photometers for precision and routine work. Eleven sources of error are enumerated, their magnitudes and methods of reducing or eliminating them are discussed. A short description of existing electrometer and thermionic-bridge photometers in use and of recent modifications thereon concludes the section.

HETEROCHROMATIC PHOTOMETRY (*pp.* 139-140).

Spectrophotometry.—The spectrophotometer in use in the Photometry Division has been modified by the employment of an improved light-source. The old and the improved light-sources are described.

Flicker Photometry with Large Colour Differences.—A comparison between spectrophotometric and flicker photometer measurements of the transmissions of twenty glasses and solutions is in progress. The transmissions for light of colour temperature 2360° K range from 5 per cent. to 70 per cent., and include several red, orange, green, and blue-green signal glasses, daylight glasses and the Ives solutions. The two methods are found to be in agreement to within 5 per cent. for the glasses investigated whose effective wavelength in conjunction with light of colour temperature 2360° K is greater than 0.54μ. For many it is better than 2 per cent.

MAINTENANCE OF STANDARDS (pp. 140-141).

Primary Standard of Light.—The work on the primary standard of light proposed by the Bureau of Standards has been actively pursued. The proposed standard—which consists of a black-body immersed in freezing platinum—is described, and the more important dimensions are stated.* Over 200 melts and freezes have been observed.

Reference is made to work with a carbon-tube vacuum furnace. It has been found that this type of furnace is unsuitable for realizing the proposed primary standard of light, since the carbon of the furnace penetrates the platinum ingot and lowers the melting and freezing-points.

International Comparison of Transmission of Four Blue Glasses (p. 141).—The results of the measurements on four blue glasses, which were made at four national laboratories by three methods, were given in the Report for 1930. In the spectrophotometric measurements there were a few discrepancies at certain wavelengths. The present Report gives the results of more recent spectrophotometric measurements at this Laboratory.

International Comparison of Photometric Standards (*pp.* 142-143).—Details are given of the values of candle-power obtained on a group of ten carbon-filament lamps, operating at carbon-lamp colour (about 4 watts per horizontal candle) by measurements at the Bureau of Standards at Washington, the National Physical Laboratory, Teddington, the Laboratoire Central d'Electricité, Paris, and the Physikalisch-Technische Reichsanstalt, Berlin. From the results the following ratios of the units at present in use in the three laboratories using the international candle have been computed; B.S./N.P.L., 0.9983; L.C.E./N.P.L., 1,0012. The relation of the Hefner candle to the international candle was stated in 1909 to be 1 Hefner candle = 0.9 international candle. The ratio from the results of the present investigation is 0.8857.

WORK FOR THE ILLUMINATION RESEARCH COMMITTEE (*p.* 143).

Reference is made to further work in connection with an investigation into the effect of glare on brightness difference threshold (white light).

Photometric Pupillometer (*pp.* 143-144).—For determining the pupil area in various conditions of illumination, a pupillometer has been designed based on a photometric principle. This instrument, and an apparatus for studying the sensitivity of the retina, are described and illustrated. The curves on page 145 show the sensitivity of the retina to light entering the pupil at different points.

Other research work undertaken for the Committee, to which reference is made in the Report, include the following:—

Reflected Daylight Factor in Deep Rooms (*pp.* 145-174).—This includes work on a large-scale model with unobstructed window and on a small-scale model with vertical obstruction facing the window.

Particle Size and Concentration in Opal Glasses (*pp.* 147-148).—A microscopical investigation of the size and concentration of diffusing particles in a series of opal glasses has been completed. Curves are given showing the variation of particle size and number in pot-opal glass (large particles), pot-opal glass (small particles) and flashed opal.

* The method of heating is by high-frequency current in a surrounding cylindrical coil.

Road-traffic Signals (*p.* 148.)—Several types of road-traffic signals have been examined and curves of light-distribution have been determined.

Motor-car Headlights (*pp.* 148-149).—Outdoor determinations of the degrees of glare experienced by a driver approaching a headlight-carrying-car have been made. Arrangements are in train to observe the visibility in a headlight beam in fog, to see whether a coloured headlight beam presents any definite advantage over a white beam.

Dock Lighting (*p.* 149).—A booklet of recommendations on dock lighting has been approved and transmitted to the Home Office.

Under-water Illumination (*p.* 149).—An investigation has been undertaken to determine the transmission of light by water, with the object of ascertaining the best methods of illuminating submerged objects. Two series of experiments are described. Determinations were made of the transmission of light by samples of tap-water and sea-water. No results capable of immediate practical application were obtained. W. B.

178. Methods of Measurement of Surface Brightness of Lighthouse Optics. A. Blondel.

Rev. d'Optique, XII, No. 3, *p.* 97, *March*, 1933.

The author discusses the problems involved in the measurement of the apparent brightness of lighthouse lenses, upon which depends their intensity. The brightness of each prismatic element is explored point by point, using either (i) an image of a small aperture placed close to the element, formed on a photometer screen, or (ii) a photometer viewing the element directly, using Maxwellian view. Details of the instruments are given. Results are not included. J. M. W.

179. On the Precision of Visual Photometry. Y. le Grand.

Rev. d'Optique, XII, No. 4, *p.* 145, *April*, 1933.

An experimental study of the influence of the form and size of the photometric field; the lines of separation of the contiguous parts, etc., upon the contrast sensitivity of the eye and the photometric accuracy. A distinction is drawn between the two, for the latter is influenced by such factors as the ratio of the gearing of the control arrangements, which it is stated should not be too great. A half-turn of the control knob should suffice to traverse from a definite out-of-balance in one direction to a similar condition in the reverse sense. The conditions for high accuracy are:—

(1) Absence of colour difference; brightness to within certain limits.
(2) Absence of lines of separation between contiguous parts.
(3) Field should be as large as possible, consistent with uniformity of brightness.
(4) Suitable arrangements of elements of field. Given absence of separating lines, the contrast type is the best; then a field, one of whose elements is a narrow central band. If separating lines exist, the form of field is immaterial.
(5) Convenient gear ratio of control knob.

J. M. W.

180. Photo-electric Colour-measuring Instruments. Herbert Neustadt.

Electronics, 6, *pp.* 128-131, *May* 1933.

A description is given of a number of photo-electric instruments, classified as colour analysers, colour comparators, and one-variable instruments for measuring a single optical property of a sample. S. S. B.

181. The Use of Photo-electric Cells Covered with Fluorescent Substances as Detectors in the Ultra-violet. P. Dubouloz.

Rev. d'Optique, XII, No. 3, *p.* 115, *March*, 1933.

Ordinary photo-electric cells covered with a layer of sodium salicylate are found to be very convenient instruments for measurements in the ultra-violet up to 3600 A. The sensitivity curve depends only on the substance used, and does not exhibit the inconvenient sharp peak characteristic of the special cells hitherto employed in this region. Results are found to be in good agreement with those by other methods. J. M. W.

182. The Infra-red Content of Daylight. G. B. Harrison.

Photog. J. (*Sci. and Tech. Supplement*), *pp.* 1-4, *April*, 1933.

A self-recording photo-electric method is described, in which the intensities of the radiations received from daylight are measured by two light-sensitive cells, both of the copper-cuprous oxide type. Of one, the spectral sensitivity curve follows that of the normal eye very closely; the other is sensitive to the infra-red. The current from each cell is passed through a mirror-type galvanometer, which reflects a beam of light focussed to a point on a rotating drum covered with bromide paper. Both infra-red and visible records are made on the same sheet. A number of records are reproduced. F. J. C. B.

III.—SOURCES OF LIGHT.

183. The Development of the Illuminating Discharge Tube. F. Skaupy.

Licht u. Lampe, 22, *No.* 10, *p.* 271, 1933; *and* 22, *No.* 11, *p.* 291, 1933.

The author traces the history of the discharge tube from Moore's patent claim in 1902 for a metal electrode with a calcium oxide filling to the present day. He quotes patents to show the developments in the construction of the electrodes, gas filling and composition of the glass. He finally summarises the difficulties to be overcome in using discharge tubes for general illumination. E. S. B-S.

184. Neon Tube Characteristics. R. W. Lohman.

Elect. Engineering, 52, *pp.* 304-307, *May*, 1933.

Information supplementing and confirming studies of voltage and current waves in neon tubes previously published are presented. It is shown that there is a peaked starting-voltage at the beginning of each wave; the current is practically zero at this point; the time during which the current wave remains at zero is negligible for a properly processed tube; and flickering will occur if the current remains at zero for even one-third of a cycle. Information on transformer regulation is also given. S. S. B.

185. Applications of Silver-processed Incandescent Lamps, with Technical Data. J. D. Walker.

Am. Illum Eng. Soc., Trans., 28, *pp.* 418-430, *May*, 1933.

This paper deals with the forms, characteristics and designs of the process for the various applications to which the silvered-bulb lamp is applied; data concerning the effect silver processing has on the operating characteristics of the lamp; the application of the silvered lamp to cove lighting, indirect lighting, industrial lighting, street lighting and special applications. Charts, graphs and other test data are included. G. H. W.

186. "Neonic" Sign Lamps. Anon.

El. Review, CXII, No. 2895, *p.* 709, *May* 19*th*, 1933.

Describes a tubular neon lamp in which metallized paper letters are assembled within the glass envelope to form words. J. M. W.

IV.—LIGHTING EQUIPMENT.

187. Traffic Signals in Piccadilly. Anon.

El. Times, 83, *p.* 680, *May* 25*th*, 1933.

Gives a brief account of the automatic traffic signals recently installed in Piccadilly. W. R. S.

188. Special Types of Standards Used for Outdoor Lighting.

El. World, 101, *pp.* 684-686, *May* 27*th*, 1933.

Three pages of dimensioned sketches showing avenue lighting and floodlighting standards in use at the "Century of Progress" Exhibition at Chicago. W. C. M. W.

189. Electric Light Flicker. A. Skowron.

El. Review, CXII, No. 2897, *p.* 774, *June* 2*nd*, 1933.

Gives an empirical curve whereby the maximum permissible cyclic irregularity of a generator, consistent with absence of perceptible flicker in lighting circuits, can be determined. J. M. W.

V.—APPLICATIONS OF LIGHT.

190. Some Observations on Illumination. R. de Valbreuze.

Bulletin de la Societe Francaise des Electriciens, No. 29, *pp.* 477-498, *May*, 1933.

This Presidential Address of the author deals generally with electric sources of light, and then discusses the diffusion of the light produced by the aid of glass and other diffusing materials. Experiments with different glasses and dispositions of the source are described and illustrated, and a diagram relating to wall-reflection is presented. A final section deals with public lighting. J. E.

191. Light and Architecture.

Am. Illum. Eng. Soc., Trans., 28, *pp.* 394-406, *May*, 1933.

After a note by A. L. Powell on "Modern Lighting from Age-old Luminaires" illustrated descriptions are given of eight modern lighting installations. G. H. W.

192. The Technical Side of Architectural Illumination. J. Roger.

Lux, pp. 53-55, *April-May*, 1933.

The author emphasizes the need for co-operation of architects with designers, decorators and illuminating engineers. Tables and curves are presented summarizing the results of comparisons between ordinary and tubular lamps, and studies of the influence of the depth of the lamp container, the form of the container, the material used in its construction, and the temperature rises experienced with encased lamps. J. E.

193. The Use of Diffusing Glass in Architectural Illumination. M. Cohu.

B.I.P., pp. 68-72, *May*, 1933.

Various systems of glass enclosures are illustrated and are shown to be applicable to a variety of premises. Curves illustrating distribution of light are presented and the question of ventilation is discussed. J. E.

194. Definition and Calculation of Characteristic Lighting Intensities of an Enclosed Space. J. Dourgnon.

R.G.E., 33, *pp.* 579-584, *May* 6*th*, 1933.

Lighting can be regarded from a point of view strictly utilitarian or from that of pleasant effect. The author points out how both these points of view lend themselves to mathematical treatment. Tables and diagrams are given and various relationships are derived. W. C. M. W.

195. Visibility of Targets Illuminated by a Searchlight. (III). J. Riviére and Y. Rocart.

Rev. d'Optique, XII, No. 4, *p.* 160, *April*, 1933.

A further instalment of the discussion in which practical cases are worked out. The article does not lend itself to abstracting. J. M. W.

196. Electric Lighting in Schools. I. Folcker.

Licht u. Lampe, 22, No. 12, *p.* 311, 1933.

The author describes the results of tests of various forms of lighting: (O) obsolete, opal shade, (1) direct with opal-glass reflector, (2) quarter indirect, (3) semi-indirect, and (4) a combination of (1) and (3) to determine their suitability for classrooms. A table is given summarizing such useful data as the efficiency, strongest shadow expressed as a percentage, illumination on the desks and blackboard, etc. He finally deals briefly with the cost of maintenance. E. S. B-S.

197. The Merchant Taylors' School, Rickmansworth. Anon.

El. Review, CXII, No. 2896, *p.* 742, *May* 26*th*, 1933.

Describes and illustrates some of the lighting installations at the new school premises at Rickmansworth. J. M. W.

198. Demonstration Show Window Sells Lighting. Anon.

El. World, 101, *pp.* 620-621, *May* 13*th*, 1933.

Describes results obtained with a demonstration of high-intensity show-window lighting. The window was loaned to local merchants for weekly periods, and has proved successful in convincing them of the advantages of high-intensity lighting. An analysis of the attracting power showed that with 1,000 watts of lighting per foot run, which included colour-effects, eight out of every ten passers-by stopped to look at the display. W. C. M. W.

199. Lighting for Office Buildings. W. E. Malm.

El. World, 101, *pp.* 587-589, *May* 6*th*, 1933.

Tenants of office buildings are becoming more "light conscious" and are demanding greatly increased illumination values. There is thus a demand for increased efficiency in the control of illumination values, and photo-electric control is advanced as a possible solution. Tables are given comparing the amounts paid for current for lighting purposes by a number of different offices. W. C. M. W.

200. Solar Illumination of the Interior of Large Buildings.

Civil Engineering, Vol. XXVIII, pp. 147-149, *No.* 322, *April*, 1933.

Report of the discussion on the "Arthel" system, described in the March issue of *Civil Engineering*, at the joint meeting of the Societe des Ingenieures Civils de France and the Institution of Structural Engineers. J. E.

Lighting Service Bureau Touring Demonstration

An enterprising departure by the E.L.M.A. Lighting Service Bureau, the equipment of a special touring demonstration van, is illustrated in the accompanying picture. This motor van, besides itself serving as a symbol of lighting service, will carry facilities for the following demonstrations: —

Full-scale colorama—showing the possibilities of painting with light.

Completely equipped demonstration shop window.

Floodlighting possibilities on a large-scale model building.

Illuminated cupboards, niches, and other conveniences for the home.

A special demonstration, enabling industrial lighting to be analysed.

Full ranges of lighting fittings for factories, shops, and offices.

Demonstrations showing how light magnifies fine detail and assists the speed of vision.

The vehicle is equipped with a 15-kw. generator, so as to serve as a source of electricity where an adequate supply is not available. Floodlighting equipment enabling the exterior of any building where a display is given to be illuminated is also available.

The equipment includes a cinematograph projector to show instructional films, and an optical lantern equipped with 500 lantern slides.

A View of the New E.L.M.A. Lighting Service Bureau Demonstration Van.

This outfit, and the services of a competent lecturer, is offered free of charge to the local electrical industry for a period of 3 to 12 days, provided a suitable hall for the display, a supply of electricity, assistance in erection and dismantling apparatus, parking and garage facilities for the car, and the publicity necessary to assemble the audience are forthcoming. We have no doubt that these demonstration facilities will be in general demand.

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Director: "What *is* the matter with our electric light these days? We seem to have less light and to pay more for current than ever before."

Manager: "I'm afraid we made the mistake of installing 'cheap' lamps at the beginning of the winter. They lose light very quickly and replacements have been unduly heavy. We shall not make the same mistake again, but in future will use only

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Floodlighting the Royal Bath Hotel, Bournemouth

We reproduce below a view of an extremely interesting installation which was carried out during the I.M.E.A. Convention, the floodlighting of the Royal Bath Hotel, Bournemouth, with the new Mazda "Mercura" lamps. The installation was undertaken by the British-Thomson-Houston Co. Ltd., in co-operation with the Bournemouth and Poole Electricity Supply Co. Ltd., and the illumination was furnished by 36 of these new luminous-discharge lamps, the light of which is emitted from electrically excited mercury vapour at high pressure. The colour of the light, whilst not of course of daylight quality, is much less removed from it than the light of the old low-pressure mercury-vapour lamp. In the case of the Royal Bath Hotel, which is constructed of grey stonework, the effect was judged to be quite natural and pleasing. The centre portion of the hotel, over the portico, was, by way of contrast, lighted by a number of projectors containing standard Mazda gasfilled tungsten lamps.

A 400-watt lamp of this description is stated to give a light-output equivalent to that of a 1,000-watt gasfilled tungsten lamp, yielding 45 lumens per watt as compared with the 15 lumens per watt yielded by the latter. The overall dimensions are $11\frac{1}{2}$ ins. long and $1\frac{7}{8}$ ins. diameter, the actual source being contained in an inner tube measuring 7 ins. by $1\frac{3}{8}$ ins. Mazda Mercura Lamps may be used on ordinary supply voltages, and no external starting apparatus is required. The only auxiliaries needed are a choke in series with the lamp to provide a stable characteristic and a 20-mf. condenser across the line for power-factor improvement.

Visit to Canada and The United States of America

Our attention has been drawn to the forthcoming visit to Canada and the United States which is being arranged by the Institution of Gas Engineers in response to invitations conveyed by the Canadian and American Gas Associations. The tour will extend from September 8th to October 16th, and will include participation in the 26th Canadian Gas Convention, the 15th American Gas Convention and the Chicago Centennial International Exposition. The present year—the 70th year of the Institution, is an opportune one for the visit, which promises to be an exceedingly interesting one. The party will leave Liverpool on September 8th on the 20,000-ton s.s. "Duchess of Bedford." The inclusive cost of the tour should not exceed the relatively moderate figure of £130.

We have been asked to mention that whilst the tour has been primarily arranged for members of the Institution of Gas Engineers, members of the Illuminating Engineering Society or the Association of Lighting Engineers who desire to join the party are welcome to do so. Those interested should communicate with Mr. J. R. W. Alexander, the Secretary of the Institution of Gas Engineers, 28, Grosvenor Gardens, London, S.W.1.

The Esplanade Hotel, Scarborough

A Pleasing Floodlighting Installation.

We take the opportunity of illustrating another recent floodlighting installation, which has won praise from the proprietor of the Esplanade Hotel, Scarborough. This installation was carried out by Messrs. Drake & Gorham Ltd., utilizing four Holophane Projector Units equipped with 1,500-watt gasfilled lamps, and two Holophane Projectors with

500-watt lamps. The four larger units are fixed on oak posts 30 feet apart facing the front of the building, whilst the smaller units are suspended on trees so as to illuminate the right and left portions.

The photograph gives a good impression of the excellent effect produced.

Illuminating Engineering in Japan

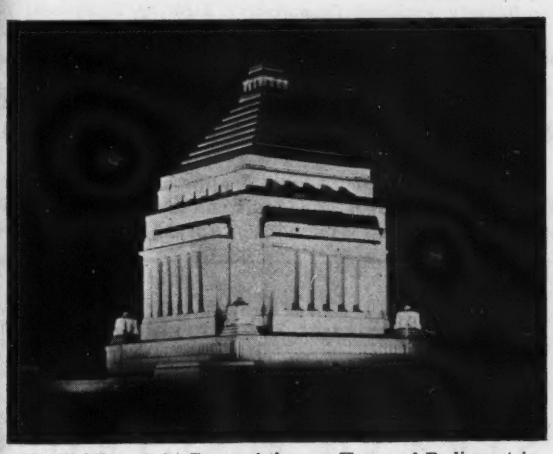
By the courtesy of Dr. Ziro Yamauti, of the Electrotechnical Laboratory of the Ministry of Communications, Tokyo, who is paying a visit to this country, we reproduce on the opposite page a series of attractive pictures illustrating progress in illuminating engineering in Japan.

These installations suggest that there is little in European lighting technique that is not also practised in the Far East.

A Golf Course in Tokyo floodlighted, for evening practice, by thirty-two 500-watt projectors.

The Neon Tower at the Ginza Palace, a new restaurant in Tokyo, on which 1,000 metres length of tube is used.

A view of the Shibaura Electrical Construction Works: Overhead general illumination from 750-watt lamps, near the roof, supplemented by 300-watt lamps on the walls, is provided.

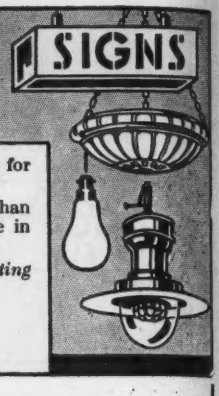


Floodlighting of the Tower of the new Houses of Parliament in Tokyo, now under construction. White stone is being used for the building, one side of which is lighted by sixteen 1,000-watt projectors.

Floodlighting of Osaka Castle, a building constructed according to traditional Japanese design. Twenty-four 1½-kw. units are used in this installation.

Some Examples of Modern Lighting in Japan

·WHERE TO BUY·
A DIRECTORY OF LIGHTING EQUIPMENT



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These terms are equivalent to **half our ordinary advertising rates**, but not less than 12 successive monthly insertions can be accepted on this basis, and amounts are payable in advance.

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Any readers having these copies for disposal are requested to communicate with THE ILLUMINATING ENGINEER, 32, Victoria Street, London, S.W.1.

Erratum

Our attention has been drawn to an error in the report of the remarks made by Mr. F. C. Smith in the discussion of Lieut.-Commander Haydn T. Harrison's paper on "Principles of Directive Street Lighting." The sentence appearing on p. 155 of our last issue, relating to an installation in Sheffield, and commencing "Although the illumination was increased," etc., should read "Although the total flux on the road surface was reduced by the use of the special type of directional reflector employed, the visibility was undoubtedly improved."

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Siemens Neonic Lamp Signs

A highly interesting novelty, the Siemens Neonic Lamp, is illustrated in Fig. 1, whilst Fig. 2 shows the appearance of a typical sign in which these lamps are employed. This is a new development of a neon-filled lamp for operation on normal supply voltages. There are no high-frequency coils nor high-tension transformers. The lamp is merely plugged into an ordinary socket in the usual manner. The lamp carries a contact at either end, one connected to the anode and the other to the cathode, and dimensions are standardized so that each lamp will accommodate a maximum of ten bold and clear-cut letters. These lamps have evident advantages, and can be used with advantage as direction indicators, counter signs or for shop-window announcements. Letters or messages are assembled within the tubular lamp, and appear with the characteristic orange-red glow associated with neon gas, yet the lamp is practically cold in operation. Signs can be readily interchanged by merely substituting another lamp in the sockets. They are exceedingly economical, as is illustrated by the fact that a single sign lamp telling its message consumes during a 10-hour day only one-twentieth of a unit.

Fuller particulars are given in a leaflet recently issued by Siemens Electric Lamps and Supplies Ltd.

FIG. 1.—A View of the Neonic Lamp.

FIG. 2.—The Complete Sign.

Floodlighting at Swansea

When the ceremony of laying the foundation-stone of the new Tir John Power Station at Swansea was recently performed by Sir Andrew Duncan many public buildings in Swansea were floodlighted.

University College, Swansea, floodlighted by night.

The illustration shows the appearance of University College, Swansea, by night. This effective installation was carried out by the Swansea Corporation Electricity Department with Siemens projectors and Siemens gasfilled lamps.

G.V.D. Illuminators

We learn with interest from G. V. D. Illuminators that a laylight system, utilizing the method recently described in this journal, has recently been installed by them in the Tate Gallery, and has been tested and approved by the Office of Works. Other types of units have been installed in some of the rooms at the New Geological Museum, where the World Economic Conference has been proceeding. G.V.D. Illuminators also state that they have secured the contract for lighting the whole of the windows of Gamages (West End) Ltd., which is now renamed British Industries House, and is to be used as a permanent exhibition of British goods.

Street Refuge Lighting

The G.E.C. Illuminated Bollard for Road Island Refuges.

The illuminated bollard shown above has been recently introduced in London, and seems likely to prove a useful traffic-device. The ingenious system of concealed lighting causes it to stand out plainly, and the whole design is robust and practical.

Sheffield Illumination Society

The Sheffield Illumination Society held its annual outing on Saturday, June 17th. The party first paid a visit to the ancient city of Lincoln, where various objects of local interest were seen. It was observed that floodlighting has been installed above the Angel Choir in the Cathedral. The return journey was made via Newark, where a short stay was made.

"Twenty-One Years"

An illustrated booklet published under the above title surveys the work of the British Electrical and Allied Manufacturers' Association since its foundation in 1911, and the progress of the electrical industry during the years that have since elapsed. The account makes interesting reading. The British electrical industry has grown until it is to-day one of the world's three largest exporters of electrical goods, and it is remarked that members of the B.E.A.M.A. manufacture 97 per cent. of the total value of electrical machinery and apparatus produced in Great Britain.

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● Similar figures could be quoted from other districts.

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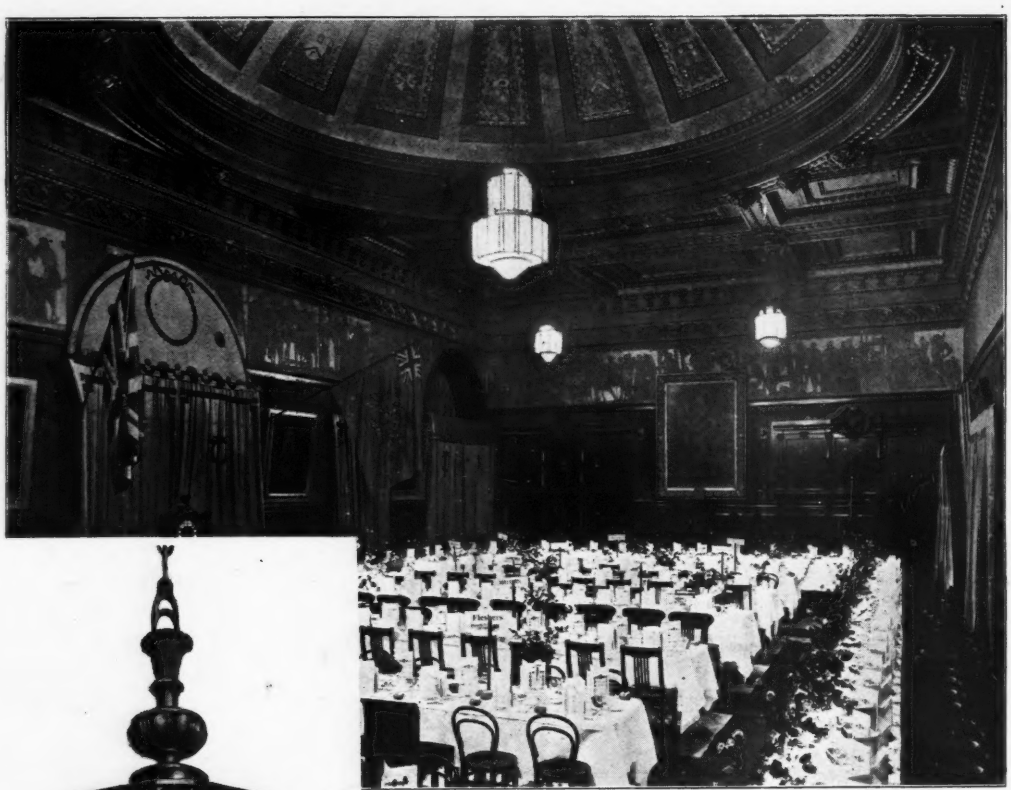

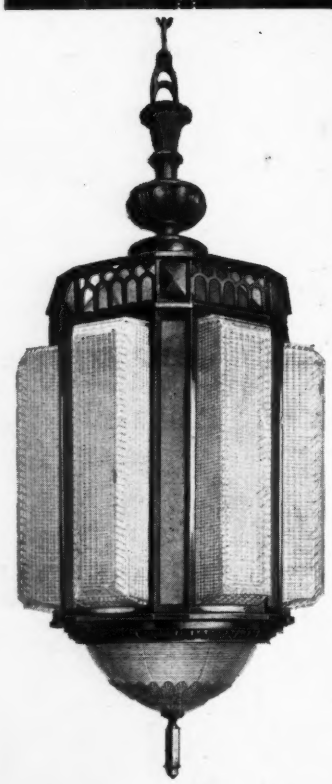

Night Photograph taken by light from fittings

THE illumination of this historic building called for very special designs to conform with the architectural and traditional features. Ultimately a unit similar to that illustrated was adopted, excepting that the Trades House Crest was incorporated.

This is only a typical example of how Holophane prismatic glassware can be adapted to suit even the most exacting lighting and architectural conditions.

WE shall be pleased to co-operate with you—also to send you any of our practical booklets.

HOLOPHANE

1, ELVERTON STREET, VINCENT SQ., LONDON, S.W.1

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